

On real and abstracted geometries of boreal forest plants - Preliminary results for real geometries

L. Aro¹ and A.T.K. Ikonen²

¹ *Finnish Forest Research Institute, Kaironiementie 15, FI-39700 Parkano, Finland*

² *Posiva Oy, Olkiluoto, FI-27160 Eurajoki, Finland*

Abstract. In Finland, Olkiluoto Island on the western coast has been selected as a repository site for spent nuclear fuel disposal. A safety criterion is that typical doses to flora and fauna should be demonstrated to be lower than those that according to best available knowledge could cause detrimental effect. To increase the confidence of dose assessment to flora, some selected plant species were measured in field conditions. This paper represents some preliminary results for dimensions and dry mass of plant species in boreal forests.

1. INTRODUCTION

In Finland, Olkiluoto Island on the western coast has been selected as a repository site for spent nuclear fuel disposal. With approaching licensing steps (application for nuclear construction licence in 2012), the biosphere assessment demonstrating the long-term safety of the repository is developed into more and more site specific. One of the safety criteria is to demonstrate that typical doses to flora and fauna remain, with high confidence, smaller than those that could, based on best available scientific expertise, lead to any detrimental effects. Based on earlier test case and assessment results, and on an international BIOPROTA study [1], the expected dose rates to the biota are in most cases small and variations within the size of the assumed geometry contribute little to the overall uncertainty.

However, in the context of providing site-specific input data to the assessment, and on the other hand at the same time aiming at conceptual integrity, defining appropriate dimensions for the ellipsoids representing plants is in most cases difficult as the shape and structure of the plants clearly deviate from an ellipsoid - unlike the case with most animal species.

In this contribution, real shapes and respective ellipsoids as defined in the assessment methodology are compared based on series of measurements at and near the Olkiluoto repository site. The relationship between real and abstracted geometries are discussed in the final paper, and from the comparison, conclusions are drawn on the needed interpretation process and on the potential of using alternative geometries for the boreal forest plants included in the study.

2. MATERIAL AND METHODS

2.1 Plant species

In this study selection of key plant species was based on earlier vegetation inventories at Olkiluoto [2], frequency of plant species and their importance in

food chains. Hence bilberry (*Vaccinium myrtillus*) was selected to represent deciduous dwarf shrubs, lingonberry (*Vaccinium vitis-idaea*) evergreen dwarf shrubs, chickweed wintergreen (*Trientalis europaea*) and wood-sorrel (*Oxalis acetosella*) lower herbs, wavy hair-grass (*Deschampsia flexuosa*) grasses, reindeer lichen (*Cladina rangiferina*) lichens and red-stemmed feather-moss (*Pleurozium schreberi*) mosses on mineral soil sites. All the selected plant species belong to a group of most common plant species in Southern-Finland [3]. Red-stemmed feather-moss also is commonly used as a bioindicator species in environmental studies. Scots pine and Norway spruce dominate forests on Olkiluoto Island [4].

For mire vegetation, bog bilberry (*Vaccinium uliginosum*), heather (*Calluna vulgaris*) and Labrador tea (*Ledum palustre*) were selected to represent dwarf shrubs and cloudberry (*Rubus chamaemorus*) herbs.

Selection criteria for the reference organisms include ecological niche, intrinsic radiosensitivity, radioecological sensitivity, distribution (e.g. presence year-round), suitability to research and monitoring and protected status [5]. It seems that the criteria are quite well in accordance with the key species we have selected for this study. However, intrinsic radiosensitivity of the selected species is an uncertain issue, especially regarding long-lived radionuclides characteristic to releases from deep repositories.

2.2 Sites

Three of the study sites located at Olkiluoto (Table 1, see also [6]). FIP4 is an intensively studied forest monitoring plot. FET measurement plots constitute a grid of systematically located plots with the purpose of describing the biomass distribution of forests and monitoring changes in the tree stands [4]. Lastensuo mire (area 440 ha, elevation 44-48 m a.s.l.) belongs to the sites chosen as analogues to the mires expected to form with post-glacial land uplift in Olkiluoto (see [7], and the paper by Haapanen et al. to this conference) and is located relatively near to Olkiluoto Island, in Eurajoki municipality. The centre of this raised bog is almost treeless, Scots pine being the dominant tree species in forested areas of the mire.

Table 1. Basic information on study sites including dominant tree species.

Site code	Site type	Tree species	Stem volume (m ³ /ha)
FIP4-OA4	Herb-rich heath forest	Scots pine	242
FET923279	Xeric heath forest	Scots pine	66
FET925276	Rocky forest	Scots pine	32
Lastensuo mire	Sphagnum fuscum bog - tall-sedge fen	Scots pine	0 - 88

2.3 Sampling and measurements

Plants species were measured from plots (radius 9.77 m) where two inventory lines were placed from south-west to north-east and from south-east to north-west (Fig. 1). On the FIP4 intensive monitoring plot only one inventory line (length 30 m) was used due to different design and monitoring system of the plot. Width in two directions and height of selected plant species were measured with an accuracy of 0.5 cm systematically along inventory lines. Only living part of mosses was measured. A subset of the plant individuals and blocks of moss and lichen were sampled for dry mass (105°C) determination in a laboratory. Because of different habitat demands of plants all selected species were not occurring on every site.

2.4 Dose calculations

In the full paper, doses of ionising radiation from repository release scenarios to the studied biota are compared between the site-specific inputs and the default data provided by the ERICA Assessment Tool [8] used in the calculations.

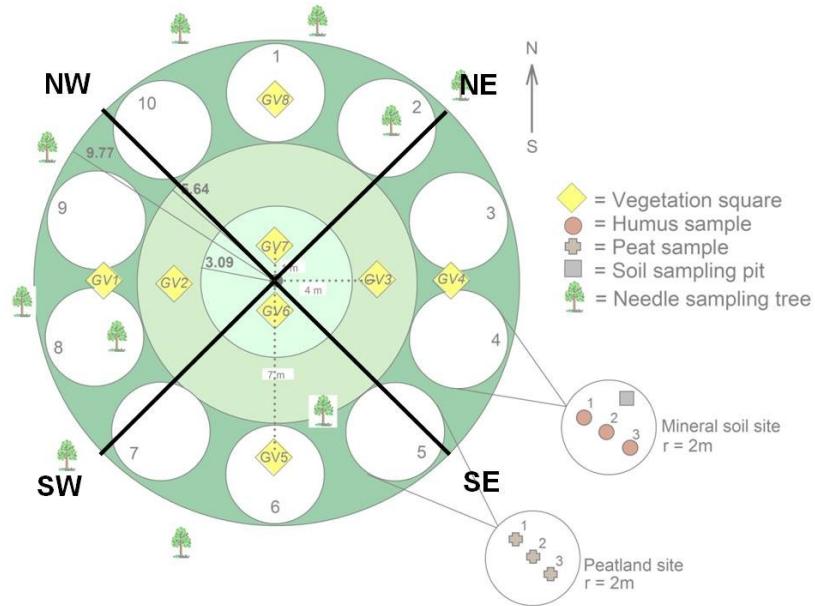


Fig. 1. Sampling design on the 300 m^2 circular plot. Two inventory lines for plant survey were placed from south-west (SW) to north-east (NE) and from south-east (SE) to north-west (NW).

3. RESULTS AND DISCUSSION

Measured dimensions of studied plant species are presented in Table 2. Leaves and inflorescences of *Deschampsia flexuosa* were measured separately since the dry mass distribution of that grass is polarized. It will be an interesting question how to combine results to represent only one set of dimensions for individual grass plant. Dry mass of single plants varied from 0.01 to $5.90 \text{ g}_{\text{dw}}$ on mineral soil sites. Bilberry had the largest dry mass and grass and herb species the

smallest ones. On the pine mire the dry mass of individual plant species varied from 0.17 (cloudberry) to 4.23 (heather) g_{dw}. Large variation in dimensions of mire plants was observed, including also dry mass of mire plants. This was an expected result because of diverse site types on Lastensuo mire.

Some practical difficulties were observed during the field work. First, how to assess that individual plant species are really developed to their full extent. On the other hand, do we need data for dose calculations of plants in their different developmental stages? It would also be very important to find a reliable method or practise for determining biological age of perennial plants. Measuring of lichens should be done very carefully not to destroy the study object.

Table 2. Measured dimensions (cm, arithmetic mean \pm std, N in parentheses) of studied plant species by site type. (¹ *D. flexuosa*, inflorescence)

Site	Species	Width 1	Width 2	Height
Mire	<i>Calluna vulgaris</i>	24.6 \pm 4.5 (14)	16.4 \pm 2.8 (14)	22.0 \pm 1.8 (14)
	<i>Ledum palustre</i>	49.2 \pm 7.7 (6)	41 \pm 8.2 (6)	59.5 \pm 5.3 (6)
	<i>Vaccinium uliginosum</i>	21.1 \pm 5.4 (7)	11.7 \pm 2.3 (7)	32.7 \pm 8.8 (7)
	<i>Rubus chamaemorus</i>	11.8 \pm 0.7 (33)	8.2 \pm 0.4 (33)	12.6 \pm 0.8 (33)
Rocky forest	<i>Vaccinium myrtillus</i>	12.7 \pm 1.3 (21)	11.3 \pm 1.1 (21)	20.2 \pm 1 (21)
	<i>Vaccinium vitis-idaea</i>	4.3 \pm 0.5 (18)	4 \pm 0.4 (18)	11.0 \pm 0.6 (18)
	<i>Trientalis europaea</i>	5.8 \pm 0.3 (10)	6.1 \pm 0.4 (10)	10.1 \pm 0.4 (10)
	<i>Deschampsia flexuosa</i> ¹	6.0 (2)	3.3 (2)	59.5 (2)
	<i>D. flexuosa</i> , leaves	13.0 (2)	10.5 (2)	17.0 (2)
	<i>Cladina rangiferina</i>	2.4 \pm 0.3 (8)	1.9 \pm 0.1 (8)	5.3 \pm 0.4 (8)
	<i>Pleurozium schreberi</i>	1.9 \pm 0.1 (12)	1.4 \pm 0.1 (12)	4.5 \pm 0.4 (12)
	<i>Vaccinium myrtillus</i>	24.0 (1)	13 (1)	20.5 (1)
Xeric heath forest	<i>Vaccinium vitis-idaea</i>	6.9 \pm 1 (7)	5.2 \pm 0.7 (7)	16.0 \pm 1.5 (7)
	<i>Deschampsia flexuosa</i> ¹	2.0 (4)	1.4 (4)	42.0 (4)
	<i>D. flexuosa</i> , leaves	25.0 (4)	27 (4)	13.5 (4)
	<i>Cladina rangiferina</i>	3.0 \pm 0.5 (6)	2.3 \pm 0.3 (6)	7.2 \pm 0.3 (6)
Herb-rich heath forest	<i>Pleurozium schreberi</i>	2.7 \pm 0.5 (8)	1.8 \pm 0.2 (8)	3.7 \pm 0.2 (8)
	<i>Vaccinium myrtillus</i>	21.4 \pm 1.4 (12)	19.7 \pm 1.2 (12)	25.1 \pm 1.6 (12)
	<i>Vaccinium vitis-idaea</i>	5.9 \pm 0.4 (12)	5.3 \pm 0.2 (12)	15.7 \pm 0.6 (12)
	<i>Trientalis europaea</i>	8.7 \pm 0.7 (9)	8.4 \pm 0.6 (9)	14.0 \pm 0.7 (9)
	<i>Oxalis acetosella</i>	2.6 \pm 0.1 (3)	2.7 \pm 0.1 (3)	6.1 \pm 0.3 (3)
	<i>Deschampsia flexuosa</i> ¹	5.3 (2)	6.3 (2)	53.0 (2)
	<i>D. flexuosa</i> , leaves	20.0 (2)	12.5 (2)	25.0 (2)

References

[1] K. Smith, C. Robinson, D. Jackson, I. de la Cruz, I. Zinger, R. Avila, Posiva Working report 2010-69. 92+137 p, (2010).

- [2] P. Tamminen, L. Aro, M. Salemaa M., Posiva Working Report 2007-78, 109 p, (2007).
- [3] A. Reinikainen, R. Mäkipää, I. Vanha-Majamaa, J-P. Hotanen (Eds.). *Kasvit muuttuvassa metsäluonnossa. Summary: Changes in the frequency and abundance of forest and mire plants in Finland since 1950. 2000.* Kustannusosakeyhtiö Tammi, Helsinki: 384 p.
- [4] J. Saramäki, K.T. Korhonen, Posiva Working Report 2005-39, 79 p, (2005).
- [5] International Atomic Energy Agency. *Modelling radiation exposure and radionuclide transfer for non-human species. Report of the Biota Working Group of EMRAS Theme 3. Pre-release; 2010.* 238.
- [6] R. Haapanen, L. Aro, J. Helin, T. Hjerpe, A. Ikonen, T. Kirkkala, S. Koivunen, A.-M. Lahdenperä, L. Puhakka, M. Rinne, T. Salo, Posiva Report 2009-02, 416 p, (2009).
- [7] R. Haapanen, L. Aro, T. Kirkkala, S. Koivunen, A-M. Lahdenperä, A. Paloheimo, Posiva Oy Working Report 2010-67, 217 p., (2010).
- [8] N. Beresford, J. Brown, D. Copplestone, J. Garnier-Laplace, B. Howard, C-M. Larsson, D. Oughton, G. Pröhl, I. Zinger, D-ERICA: An integrated approach to the assessment and management of environmental risks from ionising radiation: Description of purpose, methodology and application, EC FI6R-CT-2004-508847, 82 p. (2007).